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NOTE ON METHODS OF ESTIMATING POPULATION.

In the issue of this journal for December, 1895, in the course of a review of "Some Recent Contributions to Vital Statistics," Mr. Calkins expresses himself somewhat severely in regard to my use of the arithmetic, instead of the geometric, method of estimating population between census years in the Registration Reports of Michigan. I am indebted to the reviewer for voicing definitely the common prejudice against what seems to me not only the most convenient and generally practicable, but also the most accurate and scientifically correct, method of estimating population for intercensal years in many of the states of this country. It was with a full knowledge of this prepossession in the minds of many statistical writers in favor of the geometric method, and after a careful consideration of the relative advantages of the two systems, that I decided to adopt that employed in the Michigan Registration Reports since 1891, namely, the common arithmetic method, or that of adding the average annual increase between censuses as the estimated increment from year to year.

The geometric method of estimating population, like any other method, is used for two purposes: (1) The interpolation of populations between two given census years, or true intercensal estimates, and (2) the prediction of populations subsequent to the last census, or what I may call postcensal estimates. Its application to conditions such as attend the development of the population of Michigan (and certain other states) at the present time is illogical, and therefore necessarily unscientific. The reasons for its exclusion in both cases are as follows: —

(1) The geometric method assumes as a fundamental postulate that annual increments of population are proportional to the initial populations upon which they are based; as a necessary corollary, that the annual increments of population for the latter years of an intercensal period are larger than those for the early years; and, as a further corollary, that increments of population for successive periods of equal length (*e. g.*, census periods, either quinquennial or decennial) should be proportional to the initial populations upon which they are based.

In Michigan (and in certain other states), owing to the effect of immigration, interstate migration, variations in the rate of natural increase, or other factors, the annual increments or other periodical increments of population are not proportional to population, and, consequently, the geometric method is not applicable to the estimation of intercensal populations in Michigan and certain other states.

(2) In addition to its assumption of a law of increase in geometric ratio through the years of a census period, which, as stated above, does not hold good for Michigan (and certain other states), the geometric method further assumes, when applied to postcensal estimates, that "the same rate of increase will hold good as in the previous intercensal period."— (Newsholme, *Vital Statistics*, p. 4.)

This assumption is utterly untrue for Michigan and certain other states,— the rule being that the rate of increase rapidly changes from one census period to the next, and, therefore, the geometric method is especially inapplicable to the estimation of postcensal populations.

I cannot attempt, in the limited space at my disposal, to show the precise application of these principles to the estimation of population in Michigan except in a general way. I may be permitted to quote in this connection, especially as the reviewer seems to have entirely ignored it, a paragraph from the *Registration Report* which seems to me to present a full and satisfactory explanation for the rejection of the geometric in favor of the arithmetic method of estimation in the special case of Michigan.

> In brief the growth of this State in population for the past thirty years has been so much affected by immigration, and also, probably, to some extent by the decreasing rate of natural increase, that the geometric formula applicable in states and countries which increase chiefly by natural increase does not correctly express the relations of the increments of population for successive years. The crucial test of the applicability of this formula is whether the State does, or does not, as shown by successive census enumerations, show an amount of actual increase of population proportioned to the initial population shown by the preceding census. The increase of population in Michigan from 1880 to 1890 was 456,952. This number, based upon an initial population of 1,646,937 in 1880, is practically the same as that shown for the decade 1870-80, or 452,878, which was based upon an initial pópulation, in 1870, of only 1,184,059. As showing that the same conditions yet prevail, the net increase from 1890 to 1894, 147,565, may be compared with that from 1880 to 1884, 216,721. As the increase of population in successive census periods is not at all proportioned to the populations at the beginning of these periods, so the assumption that the latter years of any intercensus period would show a larger amount of increase than the earlier years,

because based upon a larger number of inhabitants, is clearly untenable, and the application of the geometric method, which postulates such proportional gain as population increases, to the estimation of population in in states where such conditions obtain, is *mathematically absurd.*

Besides the above objections to the use of the geometric method in estimating the population of Michigan, I found, in applying it practically, that it was productive of serious cyclical errors, and irregularities affecting series of vital rates that extend from one census decade to another. This is a result of the rapidly decreasing decennial rates of increase. It is the defect of the geometric system as applied to populations undergoing rapid and irregular changes that it sets up a series of periodical waves within census periods, and causes "faults," using a geological analogy, that in nowise exist in the data themselves, in passing from the rates of one decade to the next.

The arithmetic method is the simplest of application, especially to the subdivisions of a state; is easily understood by the public and executed by clerks and in small registration bureaus where the geometric method, simple as it is, would not be practicable; carries with it no implied belief in the Malthusian doctrine of geometric progression of population, which is very far from the truth in this country at present; and, lastly, most important of all, is demonstrably as correct in its estimates, or even more so, than the geometric method, both being tested by the predicted results of census enumerations.

The last claim, which is the gist of the matter, I think I have proved for Michigan in recent Registration Reports. Mr. F. S. Crum has proved the superiority of the arithmetic over the geometric method even in the case of Massachusetts (in these *Publications*, December, 1895), a state for which I should have been inclined to concede the superiority of the latter on *a priori* grounds. Of course it might be possible, by going back a hundred years and thereby getting a very small average annual increase as compared with the growth of the state at present, to obtain some very absurd results by the arithmetic method; but the absurdity would lie chiefly in the error of taking an average annual increment based upon an unduly long period. instead of employing the average annual increments of adjacent decennial or quinquennial periods.

The statistical authorities that have pronounced in favor of the geometric method are mostly those of Europe or of the densely settled Eastern States, whose conditions of growth are very similar to those of Europe. Dr. Farr's method has not flourished out of Europe. In Australasia, where English methods and English principles might be expected to have full sway, and where English nomenclature and forms of presentation of registration statistics are closely followed, the geometric method of estimating population has been unqualifiedly rejected,— not in favor of the arithmetic method, but for a plan of computation based upon natural increase and balance of migration, a method preferable to either if only accurate vital statistics and statistics of travel are kept. Even for England had the registrar-general employed the arithmetic method for estimating populations between the years 1881–91, his results would have corresponded more closely to the corrected figures for the latter years of the decade than did those obtained by the geometric method.

It has not been my purpose to prove the general superiority of the arithmetic method from its special application to a few favorable cases. Rather, it has been my intention to oppose the dogmatic assumption that the geometric method, because it has been found applicable to certain conditions of growth of population, is necessarily the "standard" method, which must be applied to all alike under penalty of being pronounced unscientific. Neither the arithmetic nor the geometric method "if correct for one is equally correct for all conditions." The only criterion of the value of a system of estimation is its conformity with census results, and, while I believe that for most of the states of this country at present the arithmetic system will be found to give the most reliable results when so tested, I am quite prepared to believe that certain states may find the geometric method the most satisfactory of all, or that the method of natural increase, or a combination of this method with that of the arithmetic method, as used in the admirable Swedish tables of Berg,[*] may give still better results.

C. L. WILBUR, M. D.,
Division of Vital Statistics, Dept. of State, Lansing, Mich.

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[*] *Några Grundrag af Sveriges Befolknings-statistik för åren 1748–1875.* Stockholm, 1878. Table 1.